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color-laboratory and then affrighted by their pranks had fled, leaving all this splendor blazing unknown under the fierce sun of the desert—for a desert it is in everything save color. The Arkaringa creek, which arises in the Musgrave range, in its southerly flow has cut itself a passage through these beds. On each side are cliffs 400 or 500 feet high wrought into the strangest of shapes and bedecked with the gaudiest colors. It seems as if nature wished to show what she could do when she took the artist's tools in her own hand. But the lesson is lost, for few mortal eyes, save now and then a wandering black fellow, more intent on hunting lizards for his dinner than æsthetic worship, have ever beheld this gigantic sport of Dame Nature. But the eye tires of it, and soon is fain to turn for rest to the somber black-green of the scrub foliage. With the exception of this brilliant tract all the rest of the interior consists of the dullest and most prosaic country; sandhills and stony table-lands *ad nauseam.*

Such is a brief and necessarily imperfect description of the great Australian desert. We can see that Australia, though often called paradoxical, is not so, but conforms to the laws of continental development. The outlines of the continent have existed from the earliest times, and the whole has gradually been built up, step by step, until we find it as at the present time. There has been no paradoxical break in nature's handiwork nor in her laws. We see here the same grand, impassive uniformity, the same disregard for time that ever characterized her work, whether it be the molding of a germ of life, the elevation of the Alps or the creation of a solar system. Future researches may amplify the conclusions drawn in this paper, but the main facts will remain unaltered.

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THE NUMBER OF SEGMENTS IN THE HEAD OF WINGED INSECTS.[1]

BY A. S. PACKARD, JR.

BY a study of the structure of the head of adult insects it is very difficult, if not impossible, to determine the number of segments in the head of winged insects. The number as given

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[1] Extracted from the forthcoming third report of the U. S. Entomological Commission.

by different authors is very variable, while it is popularly supposed that the head corresponds to a single segment, and that the different pieces are simply "subsegments." We will quote from Newport, article *Insecta*, in Todd's Cyclopædia of Anatomy and Physiology, the views perhaps generally entertained on this subject.

"According to the investigations of the most careful observers, Savigny, Audouin, Macleay, Kirby, Carus, Strauss-Durckheim, Newman and others, every segment of the perfect insect is made up of distinct parts, not always separable from each other or developed to the same extent, but existing primarily in all. It is also believed that the head itself is formed of two or more segments, but the exact number which enter into its composition is yet a question. So uncertain are the opinions held upon this subject, that while Burmeister recognizes only two segments, Carus and Audouin believe there are three, Macleay and Newman four, and Strauss-Durckheim even so many as seven. These different conclusions of the most able investigators appear to have arisen chiefly from too exclusive examinations of the head in perfect insects, without reference to the corresponding parts in larvæ. It is only by comparing the distinctly indicated parts of the head in the perfect insect with similar ones in the larva that we can hope to ascertain the exact number of segments of which it is composed. In the head of the perfect insect there ought to be found some traces of all the segments which exist in the larvæ of the same species, and in that of the more perfectly developed larvæ that undergo a true metamorphosis there ought in like manner to be found the rudiments of all the segments in the least perfectly developed. Now, the common larva of the Dipterous insect, the maggot of the flesh fly, is one of the lowest forms we have yet examined, and we have already seen that its head appears to be formed of four and perhaps even of five segments. This is the greatest number yet noticed in the head of the larva of any species. If, therefore, we can trace the like number in the head of a perfect insect, we may fairly conclude that this is the normal number of segments throughout the class. The head of the great water-beetle, *Hydrous piceus*, is remarkably well fitted for exemplifying the number of segments of which the head is originally composed, the remains of four of the segments being distinctly marked; and it also affords us a proof of the correctness of the opinions advanced by Savigny and others, that the organs of manducation are the proper articulated members of distinct segments, and are perfectly analogous to the proper organs of locomotion.

"We shall first describe the parts of which the head is composed, and then endeavor to explain the manner in which these parts have been developed from several segments to form the perfect cranium and its appendages. It has hitherto been customary with naturalists to designate the head the first segment of the body, and as every change in the nomenclature of a distinct part ought always to be avoided, unless positively required, through fear of creating confusion, we shall not deviate on the present occasion from the established mode; but when speaking of it as a whole shall consider it the first segment, while the aggregation of segments of which it is composed we shall designate individually *subsegments*, distinguishing them numerically in the order in which they appear to exist in the earliest condition of the fœtal larva."

If we apply the law enunciated by Savigny, and which holds good as a rule throughout the hexapod insects, *i. e.*, that each segment of the body of insects bears but a single pair of jointed appendages, we find that as the head of insects is provided with four pairs of appendages, viz., the antennæ, mandibles, first maxillæ and labium (or second maxillæ), there must be four corresponding segments.

While the subject becomes clearer when, with Newport, we examine an insect in the larval state, the fact that the head of insects is really composed of but four segments becomes readily demonstrated when we examine the embryo at an early stage of its existence. In our embryological studies on the Thysanurous insects (Isotoma), on Pseudoneuropterous insects (Diplax), on the beetles and the flea and Hymenoptera (*Nematus ventricosus*), our attention was specially directed to this point, and it appeared very plain and easily demonstrable that the head of winged insects of all orders consists of four segments (arthromeres) and no more.[1]

An inspection of the figures published by the different writers on the embryology of insects appears to confirm this view, and in our "Guide to the Study of Insects" (p. 20) we have given a tabular view of the four segments of the head and the appendages they bear. This view is fully confirmed by our studies on the embryology of the locust. The antennæ and mouth-parts are outgrowths budding out from the four primitive segments of the head; the antennæ grow out from the under side of the procephalic lobes, and these should therefore receive the name of antennal lobes. In like manner the mandibles and first and second maxil-

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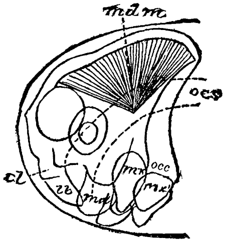
[1] See Embryological studies on Diplax, Perithemis and the Thysanurous genus Isotoma, by A. S. Packard, Jr.; Memoirs Peab. Acad. Sc., Salem, 1871, p. 21; also Second Memoir, 1872. This view was stated in the author's "Guide to the Study of Insects," second edition. Graber (Die Insekten, München, 1879, p. 430) also states that the head is composed of four segments.

læ arise respectively from the three succeeding segments. The figures by Kowalevsky and Bobretsky and by other observers, as well as those of the earliest stages of Diplax, Pulex and Attelabus which we have published, show that the cephalic segments are first indicated, and that subsequently those appendages bud out from the under side at a point situated on each side of the sternal or median line of the body. It appears that the appendages arise between the sternal and pleural portions of the segment.

There, however, remains a portion of the head in front of the procephalic or antennal lobes which afterwards becomes the clypeus and labrum or upper lip. Do these parts belong to the antennal segment, or are they rudimentary portions of a segment situated in front of our first segment? This lobe or outgrowth is evidently a single unpaired lobe which grows out in front of the antennal lobes, and is seen to form the front or upper wall of the mouth. We regard it as the tergal portion of the antennal segment, and the procephalic lobes as probably forming the pleural portion of the segment. The procephalic lobes, then, bearing the antennæ below, and higher up on the sides the eyes and ocelli, become the epicranium of the larval and adult insect. It follows, therefore, that the head of larval and adult insects is made up mostly of the first or antennal segment, and that the epicranium is the pleural portion of this segment, while the clypeus and its offshoot, the labrum, is the dorsal or tergal portion of this segment.

The only other portion of the head of certain adult insects which remains to be accounted for is the so-called "occiput." This forms the base of the head of Corydalus, a Neuropterous insect, which, however, is more distinct in the larva. In most other insects the occiput is either obsolete or soldered to the hind part of the epicranium. We have traced the history of this piece (sclerite) in Diplax, a dragon fly, and have found that it represents the tergal portion of the fourth or labial segment. In our memoir on the development of this dragon fly, Pl. 2, Fig. 9, the head of the embryo is seen to be divided into two regions, the anterior, formed of the first three segments, and the posterior, formed of the fourth or labial segment. This postoral segment at first appears to be one of the thoracic segments, but is after added to the head. A. Brandt's figure of *Calopteryx virgo*, Pl. 11, Fig. 19, represents an embryo of a stage similar to ours, where the postoral or fourth (labial) segment is quite separate from the rest of the head. The accompanying figure, copied from our memoir, also shows in a saw-fly larva (*Nematus ventricosus*) the relations of the labial or fourth segment to the rest of the head. The suture between the labial segment and the pre-oral part of the head disappears in adult life. From this sketch it would seem that the back part of the head, *i. e.*, of the epicranium, may be made up in part of the tergite or pleurites of the mandibular segment, since the mandibular muscles are inserted on the roof of the head behind the eyes. It is this segment which in Corydalus evidently forms the occiput, and of which in most other insects there is no trace in larval or adult life.



Head of embryo Nematus, showing the labial segment, *occ*, forming the occiput; *cl*, clypeus; *lb*, labrum; *md*, mandible; *mdm*, muscle of same; *mx*, maxilla; *mx'*, 2d maxilla (labium); *oes*, œsophagus.

It appears, then, that the epicranium, or that piece (sclerite) bearing the eyes, ocelli and antennæ and in front the clypeus and labrum, is formed from the original procephalic lobes, and represents the first or antennal segment, and is pleural, the clypeus and labrum being the tergal portion of the segment; while the remainder of the original or primitive segments are obsolete, except in those insects which retain traces of an occiput or fourth cephalic tergite. All of the gular region of the head probably represents the base of the primitive second maxillæ.

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EDITORS' TABLE.

EDITORS: A. S. PACKARD, JR., AND E. D. COPE.

—— The society of mutual autopsy has presented reports on the brains of several of its deceased members to the Anthropological Society of Paris. These reports are of great interest, as being among the very few accounts which we possess of the structure of the brain in persons whose characters are known to the investigators. It is clearly the only means of acquiring the foundations for a true physiology of the thinking part of the brain, which we possess. Unfortunately we are only on the threshold of the subject, owing to the almost absolute neglect of